$1.00

Simpson

INSTRUMENTS THAT STAY ACCURATE

OPERATOR'S MANUAL

MODEL 303-3XL
SOLID STATE ELECTRONIC
RECHARGEABLE VOLT-OHM-MILLIAMMETER

WARNING

For safe usage, it is essential that the operator read this manual carefully before using the instrument for any measurements.

SIMPSON ELECTRIC COMPANY

853 Dundee Ave., Elgin, Illinois 60120
Area Code 312, Telephone 697-2260
In Canada, Bach-Simpson, Ltd., London, Ontario

Warranty

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KATY INDUSTRIES
ELECTRICAL EQUIPMENT GROUP

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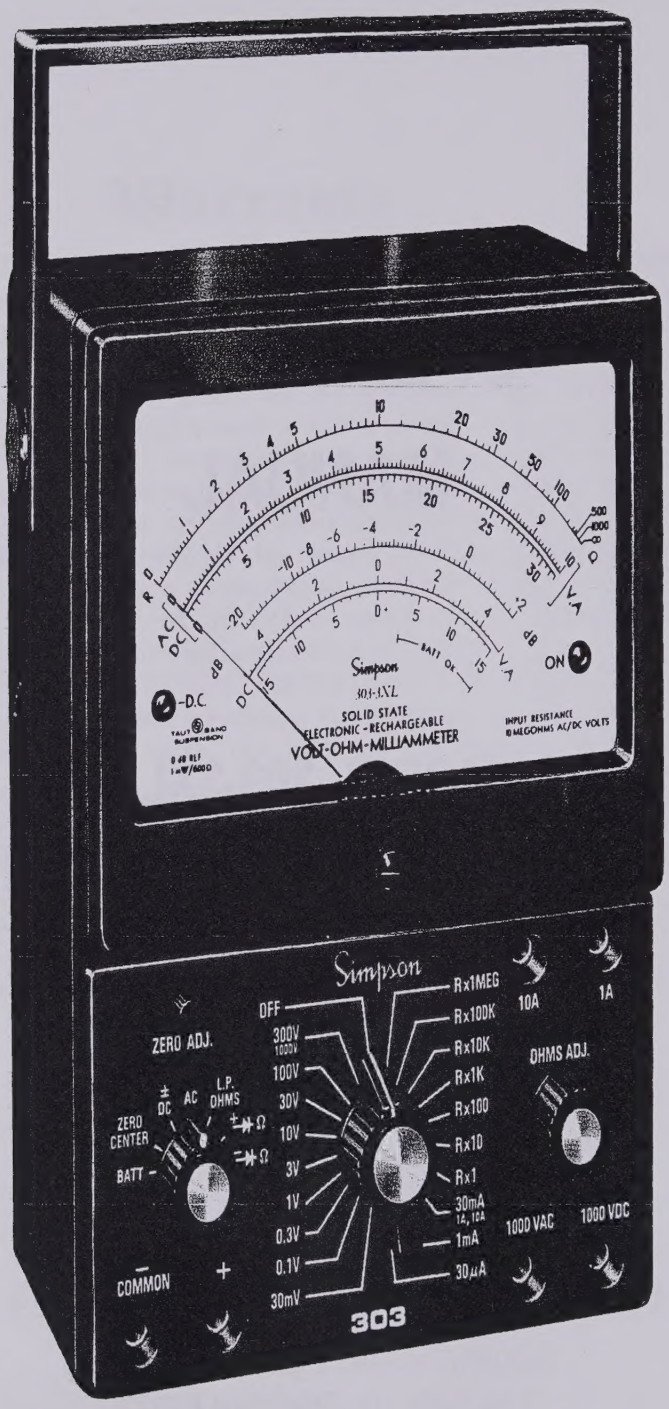

Figure 1-1. Model 303-3XL Solid State Electronic Rechargeable Volt-Ohm-Milliammeter

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SECTION I

INTRODUCTION

1.1 GENERAL

1.1.1 The Simpson Model 303-3XL Solid State Electronic Rechargeable Volt-Ohm-Milliammeter is a versatile, portable multimeter for field and factory electronics servicing, as well as electronics design and components testing. Field effect transistor (FET's), an Integrated Circuit (IC) and Light Emitting Diodes (LED's) are used in an all-solid-state circuit to achieve high input impedance, high sensitivity, and drift-free performance. Features are automatic polarity indication, low-power ohms, extensive over-voltage and over-current protection. Also, it has portable battery operation from a self-contained rechargeable cell, AC line operation, and optional operation from an ordinary "D" size flashlight-type battery.

1.1.2 The Instrument measures resistances accurately and conveniently, with protection to the circuit under test. On L.P. (Low Power) OHMS, only 30 mV is applied to the circuit under test. The error due to lead and battery resistance is so low that it is unnecessary to readjust ZERO from its setting on voltage or current ranges. Furthermore, the OHMS control needs no adjustment among the different ranges on L.P. OHMS. The capability for making junction checks of transistors and diodes is provided via DIODE OHMS; either polarity of test voltage can be applied to the test sample without reversing the test leads.

1.1.3 This Instrument indicates DC and AC voltage and current on the same scales on all ranges. DC voltage and current accuracy is within 2% of full scale. On AC, voltage measurement accuracy is within 4% from 20 Hz to 20 kHz on most ranges. AC current measurement accuracy is within 4% on all ranges. A zero-center scale is provided for special measurements such as nulling.

WARNING

This Instrument is designed to prevent accidental shock to the operator when properly used. However, no engineering design can render safe an instrument which is used carelessly. Therefore, this manual must be read carefully and completely before making any measurements. Failure to follow directions can result in a serious or fatal accident.

SHOCK HAZARD: As defined in American National Standard, C39.5, Safety Requirements for Electrical & Electronic Measuring & Controlling Instrumentation, a shock hazard shall be considered to exist at any part involving a potential in excess of 30 volts rms (sine wave) or 42.4 volts DC or peak and where a leakage current from that part to ground exceeds 0.5 milliampere, when measured with an appropriate measuring instrument defined in Section 11.6.1 of ANSI C39.5.

NOTE: The proper measuring instrument for the measurement of leakage current consists essentially of a network of a 1500 ohm non-inductive resistor shunted by a 0.15 microfarad capacitor connected between the terminals of the measuring instrument. The leakage current is that portion of the current that flows through the resistor. The Simpson Model 229-Series 2 AC Leakage Current Tester meets the ANSI C39.5 requirements for the measurement of AC leakage current and can be used for this purpose. To measure DC Leakage current, connect a 1500 ohm non-inductive resistor in series with a Simpson 0-500 DC microammeter and use this as the measuring instrument.

1.1.4 The use of a self-shielding, temperature-compensated, taut-band meter with knife edge pointer assures excellent readability, resolution, and repeatability over a wide temperature range. IC operational amplifier and low-temperature coefficient electronic components preclude need for frequent zero resetting or calibration adjustments. An FET input buffer stage provides a constant input resistance of 10 megohms on all voltage ranges.

1.2 ACCESSORIES AND SUPPLIES

1.2.1 All supplies required for operation are supplied with the Instrument and listed in Table 6-1.

1.2.2 Other accessories and replacement parts are listed in Table 6-2.

1.2.3 A probe is supplied which provides shielding for low-level signals (30 mV full scale) from high impedance sources. The probe can be used for all voltage, current and resistance measurements except 1A and 10A current ranges and 1000V. An isolation resistance of 100,000 ohms may be switched in at the probe for DC measurements requiring isolation from the cable and Instrument input capacitance.

1.2.4 Test leads are supplied for measuring the higher currents and voltages (1A, 10A, and 1000V).

1.2.5 A Battery Charger Adapter and rechargeable "D" cell are supplied, permitting AC line operation as well as portable operation on battery alone. A disposable-type (non-rechargeable) battery may be used, if desired, for portable use only.

WARNING

A non-rechargeable (carbon-zinc or alkaline) battery must not be used with the Battery Charger Adapter, since they are not vented and might result in an explosion.

1.3 TECHNICAL DATA

Table 1-1. Technical Data

1. Resistance:

L.P. OHMS and DIODE OHMS ranges: (+ → 1Ω, − → 1Ω)

RX1 RX10, RX100, RX1k, RX10k, RX100k and RX1MEG, with 10Ω at center scale.

Accuracy

On L.P. OHMS: ±1° arc (4% at mid-scale reading); subtract lead resistance on RX1 range.

On DIODE OHMS: ±2-1/2° arc (10% at mid-scale reading); subtract lead resistance on RX1 range.

Test voltage, open circuit: Less than 30 mV on L.P. OHMS and typically ±1.25V on DIODE OHMS with full charge on the rechargeable battery supplied with the Instrument.

Test Current (test leads shorted together):

OHMS RANGE	L.P. OHMS	DIODE OHMS
RX1	3 mA	±125 mA
RX10	300 μA	±12.5 mA
RX100	30 μA	±1.25 mA
RX1k	3 μA	±125 μA
RX10k	300 nA	±12.5 μA
RX100k	30 nA	±1.25 μA
RX1M	3 nA	±125 nA

Ohms Polarity: When +DIODE OHMS is selected, the ohmmeter applies +1.1 to 1.6 VDC to the positive lead; the open-circuit voltage depends upon type and condition of the battery. This voltage causes diode and transistor junctions to conduct as required for operational checks of forward resistance. When −DIODE OHMS is

selected, the polarity of voltage applied to the sample is reversed; thereby the reverse resistance of junctions can be tested without reversing the test leads. Polarity is indicated by the LED's. On +DIODE OHMS, the right hand LED flashes; on −DIODE OHMS, the left hand LED flashes. On L.P. OHMS, the right hand LED always flashes; since on L.P. OHMS, the test voltage is too low to cause appreciable diode conduction, there is no real need for reversed polarity.

*** 2. RATED CIRCUIT-TO-GROUND VOLTAGE: ("Floating" Voltage Rating)**

a. 300V max. DC or AC rms with Battery Charger Adapter connected to Instrument and AC line.

b. 1000V max.
650V max. with probe, DC or AC rms without Battery Charger Adapter connected to Instrument.

3. AC, DC Voltage Ranges (Full Scale): 30mV, 0.1V, 0.3V, 1V, 3V, 10V, 30V, 100V, and 300V. 1000 VAC and 1000 VDC ranges are available on separate jacks.

Input Characteristics:

Resistance: 10MΩ for both AC and DC ranges; 31.9 MΩ on 1000V ranges.

* NOTE, per American National Standard, C39.5 (April 1974), Safety Requirements for Electrical & Electronic Measuring & Controlling Instrumentation, RATED CIRCUIT-TO-GROUND VOLTAGE is defined to mean: "The specified voltage with respect to ground which may be safely and continuously applied to the circuits of an instrument."

Capacitance	45 pF without probe (15 pF on 1000V jacks); 150 pF with probe.
AC ("Normal Mode") rejection on DC:	−30 dB at 50 Hz
Accuracy on DC:	±2% (with probe on ISOLATION DCV). NOTE: Reading is 1% higher when probe is set on DIRECT, or if regular test leads are used.

Accuracy on AC (full-wave average sensing, RMS sine wave calibration):

	Frequency Response Within			
	50/60 Hz	400 Hz	20 Hz to 20 kHz	2 Hz to 100 kHz
.03V to 10V	2%	2%	0.25 dB	1 dB
30V to 100V	2%	2%	0.4 dB	1.5 dB
300V	2%	3%	1 dB	2 dB
1000V	3-1/2%	4%	2 dB	3 dB

Polarity: Up-scale indication occurs for either positive or negative DC voltages. For zero and positive DC INPUT voltages with respect to the COMMON jack, the right hand LED flashes. For negative DC voltage, the left hand LED flashes. For AC voltages, only the right hand LED flashes.

4. AC, DC Current Ranges (Full Scale): 30 μA, 1 mA, 30 mA. For 1A and 10A ranges, separate jacks are provided.

Voltage Drop on Current Measurements: 100 mVDC or RMS, except on the 10A range, where the voltage drop is 125 mVDC or RMS.

Accuracy (at full scale, all ranges):

DC: 2%

AC:

50 to 400 Hz	20 Hz to 20 kHz	2 Hz to 100 kHz
3%	4%	10%

Polarity: Up-scale indication for both positive and negative direct currents flowing from meter INPUT jack to COMMON jack. The left hand LED flashes for negative direct currents. On AC ranges, only the right hand LED flashes.

5. dB Readings: 0 dB reference is 0.775V across 600Ω (1 mW). Add or subtract 10 dB per range step, as follows:

Ranges:

30mV	−50 dB to −28 dB
0.1V	−40 dB to −18 dB
0.3V	−30 dB to − 8 dB
1V	−20 dB to + 2 dB
3V	−10 dB to +12 dB
10V	0 dB to 22 dB
30V	10 dB to 32 dB
100V	20 dB to 42 dB
300V	30 dB to 52 dB
1000V	40 dB to 62 dB

6. Zero Center: Pointer moves to center scale zero (on lower-most arc) upon selection of this function.

Maximum Sensitivity: 1 millivolt per division for voltage measurement; 1 microampere per division for current measurement.

7. Indicating Instrument: 4-1/2 inch, self-shielded, annular, taut-band type. Sensitivity is 192 μA full-scale; movement resistance is 234Ω.

8. Temperature Range: 0°C to 50°C

9. Overload Capability: Up to 250V may be applied momentarily to input terminals without damage on any setting. A 2A 3AG quick-acting fuse blows when excessive input is applied to a current or low resistance range shunt. The fuse is accessible within the battery compartment. A spare fuse is installed near the fuse clip. The separate 1A and 10A jacks can withstand 5 times current overload for 10 seconds (no fuse). Permissible voltage overload ratings that apply are:

Range	Overload Voltage
300V	1600 VAC or DC for 1 minute
100V	1600 VAC or DC for 1 minute
30V	1600 VAC or DC for 1 minute
10V	1600 VAC or DC for 1 minute
3V	1600 VAC or DC for 1 minute
1V	1600 VAC or DC for 1 minute
0.3V	1600 VAC or DC for 1 minute
0.1V	250 VAC or DC for 10 seconds
30mV	250 VAC or DC for 10 seconds

10. Power Requirements: The Model 303-3XL is equipped with a rechargeable, nickel-cadmium "D" size battery (see Table 6-1) (1.2. amp. hours). The Battery Charger Adapter is designed for continuous operation from 120 VAC, 50 to 400 Hz. With Battery Charger Adapter disconnected and

battery fully charged, the Instrument operates as a portable unit for about 20 hours. When fully discharged, the battery re-charge time is about 16 hours with the Instrument off, and 40 hours with the Instrument operating. For discharged or new battery, an initial charging time of one minute is recommended for operation of the Instrument on RX1 DIODE OHMS range, which requires heavy current drain. The longer life rechargeable battery, ANSI type K-90 rated for 4 amp. hours may be used optionally. Non-rechargeable battery types (NEDA No. 13, 13A, 13C and 13F) may be used only with the Battery Charger Adapter disconnected.

The BATT testing function checks the condition of the battery. The periodically flashing feature of the active LED reminds the user to turn off the meter when not in use.

11. Dimensions: 5.5 x 7.2 x 3.3 inches (140 x 183 x 84 mm)

12. Weight: 2.5 pounds (1.14 kg)

SECTION II

INSTALLATION

2.1 UNPACKING AND INSPECTION

2.1.1 Prior to unpacking, examine the shipping carton for any sign of damage. If there is none, inspect the Instrument and packing material for obvious damage from mechanical shock, water leakage or other causes. Check the electrical performance as soon as possible. If there is any indication of damage, file a complaint with the carrier immediately. Also check that all supplies are included (Table 6-1).

2.1.2 Save the shipping carton and packing materials for future storing or shipping of the Instrument.

2.2 POWER SOURCE REQUIREMENTS

Do not insert power cord plug into the power source yet. Check that the designation on the Battery Charger Adapter panel agrees with the power source to be used, and that the proper rechargeable battery is installed.

2.2.1 The Model 303-3XL is designed to be operated from a self-contained nickel-cadmium cell, furnished with the Instrument, or from the AC line using the accessory Battery Charger Adapter. Refer to Table 1-1.

NOTE: The rechargeable battery **must be installed** in the unit for operation from the AC line.

2.2.2 For battery installation and battery test, refer to paragraph 5.5.1

2.2.3 Carbon zinc (NEDA #13F) or Alkaline (NEDA #13A) batteries may be used for portable or emergency use. **DO NOT** use Battery Charger Adapter with these batteries.

2.3 INSTALLATION

The Instrument may be operated in any position. It can be inclined conveniently by positioning the Adjust-A-Vue Handle. It might be necessary to reset the meter's mechanical zero when the Instrument's position is changed. Refer to paragraph 4.3.5 for this procedure.

SECTION III

CONTROLS, CONNECTORS AND INDICATORS

3.1 GENERAL

All operating and adjustment controls, connectors and indicators are described in Table 3-1. Become familiar with each item prior to operating the Instrument for the first time.

3.2 FRONT AND REAR PANEL DESCRIPTION

Table 3-1 lists all front and rear panel controls, connectors and indicators. See Figure 3-1 for identification.

Table 3-1. Front and Rear Panel Description

1. Mode Selector (7 detented positions):

Position	Description
BATT (Spring return to ZERO CENTER position)	The meter deflection is proportional to the "D" cell voltage under normal load. A fresh carbon-zinc "D" cell indicates highest on the BATT. OK scale. A charged nickel-cadmium "D" cell indicates midway in the BATT. OK range.

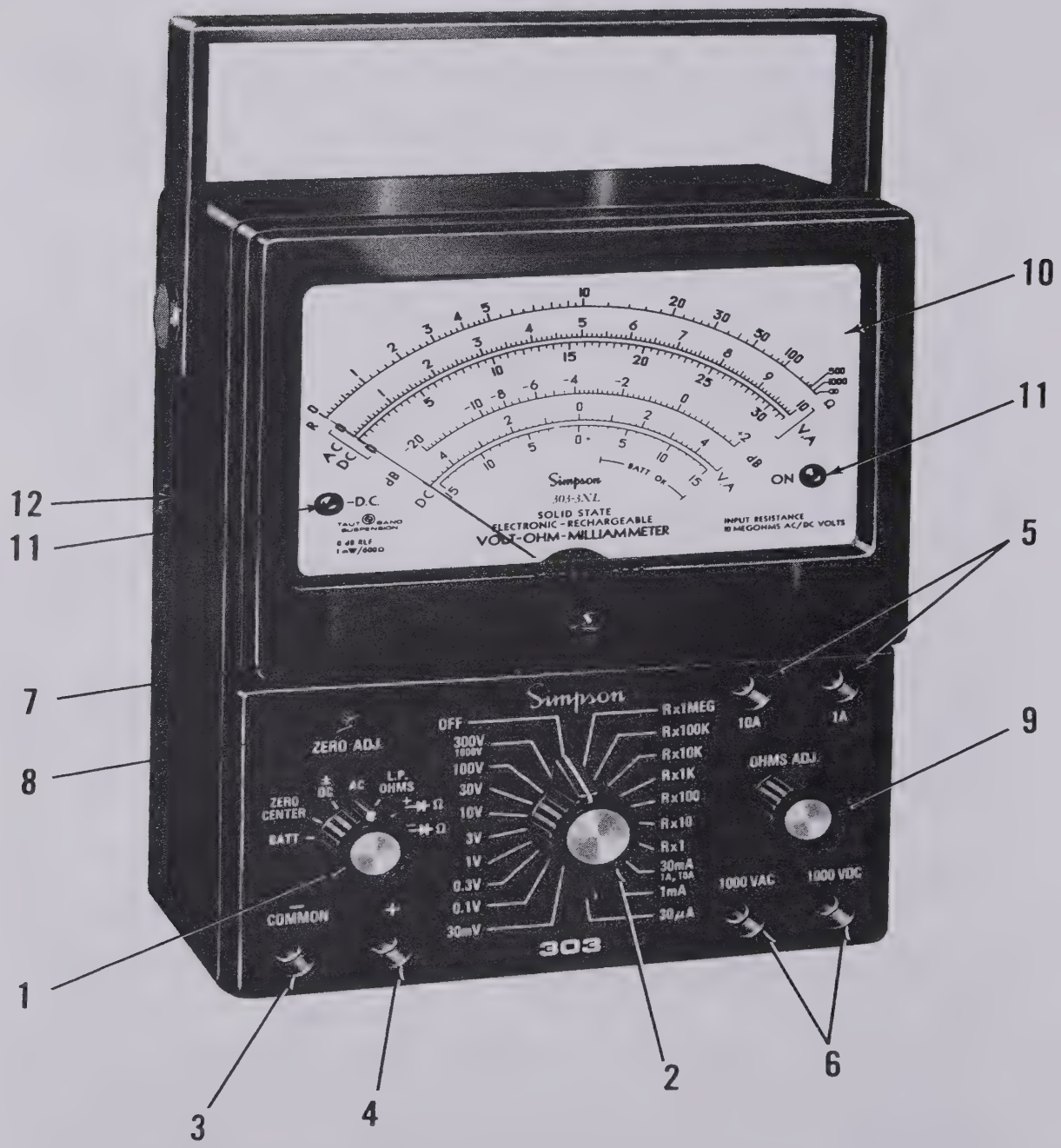

Figure 3-1. Front and Rear Panel Description

Controls, Connectors and Indicators

ZERO CENTER	The meter pointer can be offset to center. The zero-center scale is calibrated to indicate + and − values of DC voltage and current. The full-scale (+ or −) value is 1/2 that appearing on Range Selector. The auto-polarity feature is deactivated. ZERO CENTER is not used with AC or OHMS ranges.
±DC	In other than ZERO CENTER operation, indication is always up-scale, regardless of signal polarity. The left hand LED flashes for negative values of direct voltage and current.
AC	The Instrument is connected to indicate the RMS value of sine wave voltage and current. The Range Selector sets the full-scale value.
L.P. OHMS	The Instrument is connected for ohms measurement, with an open-circuit output of 23 to 33 mV, depending upon battery type and condition. In general, use L.P. OHMS when measuring resistance; it minimizes battery drain, and will not harm any semiconductors which happen to be in the circuit. Since the effect of battery resistance essentially is sidestepped, the accuracy is better on L.P. OHMS, as noted in Table 1-1.
+DIODE OHMS	Any ohmmeter measurement tends to be upset by external current sources, so always disconnect them. If you are sure there are no semiconductors in the measurement path, and need to minimize the effects of small stray potentials (ground currents, thermoelectric effects, etc.), switch to DIODE OHMS. In +DIODE OHMS operation, positive DC is on the INPUT terminal and the right hand LED flashes.

−DIODE OHMS	This function is like +DIODE OHMS except that negative DC is on the INPUT terminal and the left hand LED flashes. The −DIODE OHMS function thereby reverses the voltage across the circuit under test without need for interchanging the test leads.

2. Range Selector (20 detented positions):

Position	Description
OFF	Disconnects all battery power from the Instrument circuit. LED's are off. Does not disconnect Battery Charger Adapter when it is plugged in. Therefore, the battery can be charged when set in the OFF position. By using the recommended rechargeable battery (vented type), there is no destructive overcharge when left connected indefinitely. See section on battery charging and maintenance.
Rx1MEG, Rx100k, Rx10k, Rx1k, Rx100, Rx10, Rx1	These switch positions select the desired range setting for resistance measurement, depending upon mode selection of either L.P. OHMS, +DIODE OHMS, or −DIODE OHMS. The test leads are connected to the INPUT and COMMON jacks.
30μA, 1 mA, 30 mA, (1A, 10A)	These switch positions provide several range settings for DC or AC current, depending on the mode selection; either ZERO CENTER, DC or AC operation may be selected. When the switch is in the 30 mA (1A, 10A) position, the input current passes between the INPUT and COMMON jacks for the 30 mA range. For the 1A range, use the COMMON and 1A jacks; for the 10A range, use the COMMON and 10A jacks.

30 mV, 0.1V, 0.3V, 1V, 3V, 10V, 30V, 100V, 300V (1000V)	These switch positions provide many range settings for DC and AC voltage, depending on the mode selection; either ZERO CENTER, ±DC or AC may be selected. When the switch is in the 300V (1000V) position, the input voltage is applied to the INPUT jack for the 300V range, or the 1000 VAC or 1000 VDC jack for the 1000V range.

3. −COMMON Jack

This jack provides the input return connection for all voltage, current and resistance ranges, and connects the circuit being measured to the internal metering circuit common. It normally is connected to the ground or return side of the circuit being measured, and is isolated from the AC power line connections.

4. +Input Jack

This jack connects the circuit being measured to the internal metering circuit input. The input resistance of 10 megohms applies to all voltage ranges.

5. 10A and 1A Jacks

These jacks provide one of the input connections for the 10A and 1A ranges. The COMMON jack provides the other connection.

6. 1000 VAC and 1000 VDC Jacks

These jacks provide one of the input connections for the 1000 VAC and 1000 VDC ranges. The COMMON jack provides the other connection.

7. Mechanical Zero Adjustment

This is a phenolic screw adjustment on the meter cover used for adjusting the meter pointer to mechanical zero.

8. ZERO ADJ.

This is a 1/4" knurled knob adjustment used to set internal amplifier DC balance to zero. Frequent resetting is not needed.

Controls, Connectors and Indicators

9. OHMS ADJ.

This control is adjusted for a meter indication of "∞" with the input jacks open-circuited. No readjustment is required other than setting once, on any range, for all DIODE OHMS measurements, and once for all L.P. OHMS measurements.

10. Meter

4-1/2 inch, taut-band Instrument of 192μA F.S.

11. −DC (Left), ON (Right) LED Indicators

These LED's are positioned on the left and right sides of the meter face and indicate:

a. The meter is turned on when either LED is flashing. With no input signal, the right hand LED flashes periodically.

b. The polarity of voltage or current to which the meter pointer responds is + for right hand LED indication and − for left hand LED indication.

12. Zero Center Adjust (Internal)

A small hole in the left side of the case provides access to this adjustment of initial conditions.

13. Battery Charger Adapter Jack (Not shown in Fig. 3-1)

A hole in the rear battery compartment cover gives access to the socket for plugging in the Battery Charger Adapter.

14. Battery and Fuse Compartment (Not shown in Fig. 3-1)

Unplug the cord from the Battery Charger Adapter. Remove the cover from the battery and fuse compartment when installing a new battery or when changing the fuse. A spare fuse is included within the compartment.

15. Battery Charger Adapter (Not shown in Fig. 3-1)

The Model 303-3XL is equipped with a rechargeable "D" cell Battery

Charger Adapter. The adapter plugs into the wall socket. A cord and plug at low voltage plugs into a jack through a hole in the battery and fuse compartment cover.

CAUTION

Be sure the AC power source used matches the power requirements shown on label of Battery Charger Adapter.

SECTION IV

OPERATION

4.1 GENERAL

WARNING

The Model 303-3XL is designed to prevent accidental shock when properly used. However, no engineering design can render safe an instrument which is used carelessly. Therefore, this manual must be read carefully and completely prior to making any measurements. Failure to follow directions can result in a serious or fatal accident.

This section of the manual contains all the information required to use and operate the Model 303-3XL in a safe and proper manner. This Instrument was designed and tested to assure safe operation,

and no unsafe voltages are produced by the Model 303-3XL itself. The precautions below guide the user in safely making and breaking connections for measuring the circuit under test, as well as maintaining the Instrument and its accessories in a safe condition. Special notes and instructions also have been included for added user safety and convenience.

4.2 SAFETY PRECAUTIONS

4.2.1 The Model 303-3XL is intended for use only by personnel qualified to recognize shock hazards and trained in the safety precautions required to avoid possible injury. Refer to SHOCK HAZARD definition on page v.

4.2.2 Do not work alone when making measurements where a shock hazard might exist. Notify a nearby person that you are making, or intend to make, such measurements.

4.2.3 Voltages might appear unexpectedly in defective equipment. An open bleeder resistor in the circuit under test can result in capacitor's retaining a dangerous charge. Remove all power and discharge all capacitors in the circuit being measured and remove all power from the circuit **before** making connections or disconnections. The Instrument itself is well protected against electrical overload, as noted in Table 1-1. However, the above precautions are wise even in the laboratory, and especially in field usage of the Instrument, where many strange or unknown safety hazards might prevail.

4.2.4 Locate all voltage sources and current accessibility paths prior to making any measurement or connections. Determine what the rated voltages are supposed to be.

4.2.5 For your own safety, inspect the test leads for cracks, breaks or crazes in the insulation, prods, and connectors before each use. If any defects are noted, replace the defective item(s) immediately. Do not use test leads of lesser quality than those originally furnished with the Instrument.

4.2.6 Do not make measurements near a circuit where corona is present. Aside from danger of harm to yourself or to the Instrument, the ionized air which accompanies corona often tends to invalidate the measurements you would be making. Corona can be identified by a pale-blue color emanating from sharp metal points in or near the circuit, or by a buzzing sound, or by the odor of ozone. In rare instances such as around germicidal lamps, ozone might be generated as a normal function. Ordinarily, the presence of ozone indicates high voltage, and possibly an electrical malfunction of some kind.

4.2.7 Hands, shoes, floor and workbench must be dry. Avoid making measurements under humid, damp, or other environmental conditions that could affect the dielectric withstanding voltage of the equipment under test, or the test leads, or the Instrument.

4.2.8 For maximum safety, do not touch test leads, circuit, or Instrument while power is applied to the circuit being measured.

4.2.9 Use extreme caution when making measurements in an rf circuit where a dangerous combination of voltages could be present, such as in a modulated rf amplifier.

4.2.10 Do not exceed the RATED CIRCUIT-TO-GROUND VOLTAGE of this Instrument. See Item 2, Table 1-1.

4.2.11 Before the Instrument is used for AC operation, make sure that the "third wire" on the AC power cord is connected to an earth or power line ground

4.3 PRELIMINARY NOTES, CHECKS AND ADJUSTMENTS

Prior to operation of the Instrument, review the following notes and perform the checks (where applicable). These steps also can be used as a general functional check.

4.3.1 AC Line Operation

Be sure that the power source matches the requirements of the Instrument as marked on the Battery Charger Adapter. Plug the adapter jack into the Instrument, and then plug into a 3-wire outlet

which conforms to the latest issue of the National Electrical Code. For AC line operation, the Model 303-3XL **must** contain a Nickel-Cadmium rechargeable D size cell. While the Instrument is plugged into the AC line, the cell is being "trickle" charged. The cell also acts as a filter and a voltage regulator.

4.3.2 Battery Operation with Nickel-Cadmium Rechargeable Cell

Disconnect the Battery Charger Adapter from both the AC line and the Instrument. Check the cell condition by setting the mode switch to BATT. When the cell is fully charged, the reading will be about half-way in the BATT. OK indication span on the meter dial. In typical usage, the Instrument will operate 20 hours before recharging is necessary. If below BATT. OK span, the battery is charged insufficiently or completely discharged. New rechargeable cells are often received in the completely discharged condition, and therefore must be charged before they are put into use.

4.3.3 Battery Recharging

To charge/or recharge the cell, connect the Battery Charger Adapter for AC line operation (see paragraph 4.3.1), and turn Instrument range selector to OFF. After a few minutes, turn the mode selector to BATT. Check for a reading above the BATT. OK minimum. The Model 303-3XL now may be used on AC line and will trickle-charge the cell during use. After about 40 hours of operation on the AC line (from complete discharge), the cell will be fully charged. Thereafter, the cell will trickle-charge indefinitely with no degrading effects. To charge the cell faster (full charge is about 16 hours from discharge), leave connected to the AC line but turn the range selector switch to OFF.

4.3.4 Battery Operation With Non-rechargeable (Carbon-Zinc or Alkaline) Cell

WARNING

Do not attempt to use the Battery Charger Adapter to charge the carbon-zinc or alkaline cell or to use Instrument on AC line unless a rechargeable cell is installed.

The Instrument will operate from a single "D" size flashlight battery of the types commonly available. A flashing LED is a constant indication that the Instrument is turned ON and reminds the user to turn it OFF when not in use.

4.3.5 Functional Checks

a. Turn the range selector to OFF.

b. Connect the test probe to the Instrument, making sure that the "ground" side of the double banana plug is in the COMMON input jack.

c. Place the Instrument in the position desired for most measurements. The Adjust-A-Vue handle holds the Instrument in the desired position. With Instrument turned OFF, set the meter mechanical zero by using an appropriate screwdriver and rotating the phenolic adjusting screw clockwise (or counterclockwise) until the pointer indicates zero (0). Then back off slightly on the screw, but not enough to change the position in the reverse direction.

d. Short the test leads together by connecting the grounding lead to the probe tip. Turn the mode selector to AC and the range selector to 30 mV. The meter pointer will rest at zero (0) on the scale. If the adjustment has been disturbed, adjust the ZERO ADJ. knob on the panel.

e. Disconnect the ground lead from the probe tip. The pointer will deflect up-scale due largely to stray pickup hum.

f. Turn the mode selector to L.P. OHMS and the range selector to Rx100. Set OHMS ADJ. for infinity (∞) reading.

g. Short the ground lead to the probe tip. The meter pointer will rest at zero (0).

h. Turn the mode selector to + DIODE OHMS. The meter pointer will rest at zero (0).

i. Disconnect the ground lead from the tip. The meter pointer will deflect up-scale. Adjust OHMS ADJ. for infinity (∞) reading.

j. Turn the mode selector to − DIODE OHMS. The meter pointer will stay at infinity (∞). The left hand LED will flash periodically.

k. Short the probe ground lead to the tip. The meter pointer will rest at zero (0).

l. Turn the mode selector to ±DC and the range selector to 300V. The meter pointer will rest at zero (0).

m. Turn the mode selector to ZERO CENTER. The meter pointer will come to rest at or near center scale (zero on the zero-center scale). If adjustment is necessary, do not touch the ZERO ADJ. knob. Instead, turn the internal adjustment, using a small screwdriver inserted through the access hole on the left side of the Instrument.

n. Turn the mode selector to ±DC. This completes the preliminary operational checks and adjustments.

4.4 DC RESISTANCE MEASUREMENTS

4.4.1 Review and comply with the PRELIMINARY NOTES, CHECKS AND ADJUSTMENTS of paragraph 4.3

4.4.2 Remove all power from the circuit being measured and discharge all capacitors.

4.4.3 Rotate the mode selector to the L.P. OHMS position and set the range selector to the position that will result in a meter

indication nearest center scale for the resistance being measured. If the approximate resistance is not known, start with the Rx1MEG range. Only a very low voltage (30 mV) is applied to the circuit in the L.P. OHMS mode. It will not damage semiconductors. Since the voltage is so low, the polarity of the applied voltage has negligible effect on most readings; therefore a polarity reversal switching function is not provided for L.P. OHMS. Refer to Table 1-1, item 1, for applied circuit power in this mode.

4.4.4 With the range set at Rx100 or higher, connect the tips of the leads together. If the test probe is used, set its slide switch to DIRECT.

4.4.5 Check for a zero (0) indication on the left side of the OHMS scale. No adjustment is required if the Instrument already has been checked for zero on ±DC or AC volts. On the Rx10 and Rx1 scales, the reading will be slightly above zero. This is normal, due to the resistance of the leads. For very low resistance measurements, use the red and black test leads and subtract the lead resistance reading from the unknown resistance reading. You sacrifice accuracy in re-zeroing the Instrument to compensate for this offset.

4.4.6 Separate the tips of the test leads. The pointer will return to the right side of the OHMS scale. Set OHMS ADJ. as necessary to cause the pointer to rest over the infinity (∞) mark. No other checks or settings are required for all subsequent measurements in L.P. OHMS mode. The Instrument is ready to make circuit resistance measurements.

4.4.7 If the purpose of the resistance measurement is to check a semiconductor in or out of a circuit (forward and reverse bias resistance measurements), select + DIODE OHMS or −DIODE OHMS. Consider the following, **prior** to making the measurements:

a. Insure that the range selected will not damage the semiconductor. Refer to Table 1-1, item 1, and review the specification limits of the semiconductor according to the manufacturer's ratings.

b. If the semiconductor is a silicon diode or a conventional silicon transistor, normally no precautions are required.

c. If the semiconductor material is germanium, check the ratings of the device and refer to Table 1-1, item 1, before using the Rx1, Rx10, Rx100 ranges. When in doubt, use the Rx1K range or higher.

d. On + DIODE OHMS, the polarity of the voltage at the input jacks is the same as the input jack markings. Be certain that the polarity of the test leads is correct for the application and that the black or "ground" lead is in the COMMON jack of the Instrument. On − DIODE OHMS, the polarity is reversed.

4.4.8 With the range set at Rx100 or higher, connect the tips of the test leads together.

4.4.9 Check for a zero (0) indication on the left end of the OHMS scale. No adjustment is required if the Instrument already has checked zero on the ±DC or AC volts.On the Rx1 and Rx10 scales, the reading will be slightly above zero, due to the resistance of the leads. This error is very small and can be ignored except for very low resistance measurements.

4.4.10 Separate the tips of the test leads. The pointer will return to the right end of the OHMS scale. Set OHMS ADJ. as necessary to cause the pointer to rest over the infinity (∞) mark. No other checks or settings are required for all subsequent measurements on + DIODE OHMS, or − DIODE OHMS modes and all resistance ranges in these modes.

4.4.11 Inspect the circuit under test for parallel resistance paths other than the resistance component being measured. Parallel paths can result in a measured value which is considerably lower than expected. Error from parallel paths that depend upon conduction of a diode or transistor junction can be avoided by use of the L.P. OHMS.

4.4.12 Connect the test leads across the resistance being measured. Avoid contacting adjacent points.

4.4.13 The value of the resistance being measured is indicated on the meter.

4.4.14 Disconnect the test leads.

4.4.15 If no additional resistance measurements are required, rotate the mode switch to AC and range switch to OFF. This avoids accidental application of voltages to the ohmmeter portion of the Instrument, and conserves battery life.

4.5 DC VOLTAGE MEASUREMENTS

Do not exceed the rated circuit to ground voltage. See Item 2, Table 1-1 and the Safety Precautions tabulated in paragraph 4.2.

4.5.1 For DC voltage measurements up to 300V, connect and use the ISOLATION DCV/DIRECT probe, and place the probe slide switch in the ISOLATION DCV position. Make sure that the "ground" side of the double banana plug is in the COMMON input jack. For DC voltage measurement over 300V, connect the red test lead to the 1000 VDC jack and the black lead to the COMMON jack.

4.5.2 Review and comply with the preliminary notes and checks of paragraph 4.3, except during the checks, place the probe slide switch in the DIRECT position.

4.5.3 Remove all power from the circuit being measured and fully discharge all capacitors.

4.5.4 Turn the mode selector to ±DC and the range selector to the voltage range desired. Set the probe slide switch in the ISOLATION DCV position. If the voltage to be measured is not known approximately, begin with the 1000 volt range and use the red and black test leads plugged into the 1000 VDC and COMMON jacks, respectively; turn the range selector to the 300V (1000V) position.

4.5.5 Apply power to the circuit being measured. For maximum safety when testing circuits where voltages might exceed 30 volts, do not touch the test leads or the Instrument when circuit power is turned on.

4.5.6 After measurement, remove all power from the circuit, discharge all capacitors, and disconnect the test leads from the circuit.

4.5.7 Zero Center Voltage

When seeking zero adjustment in a DC circuit which might have either positive or negative output polarity (as when adjusting a Wheatstone bridge, or a discriminator), you can watch the LED's to keep track of polarity. Often, however, it is convenient to swing the pointer up to center scale. You can have zero center without upsetting other adjustments, merely by setting the left hand selector switch to ZERO CENTER. The automatic polarity indication feature does not apply in ZERO CENTER operation. Positive voltages (with respect to COMMON) are read up-scale from center zero. When used as a null or balancing indicator, the Instrument's voltage range setting may be reduced progressively to obtain the desired sensitivity.

4.6 AC VOLTAGE MEASUREMENTS

4.6.1 General

Do not exceed the rated circuit to ground voltage. See item 2, Table 1-1 and the Safety Precautions tabulated in paragraph 4.2.

Follow the same directions as for DC voltage measurements (paragraph 4.5), except set the probe slide switch to DIRECT and turn the mode selector to AC. The ZERO CENTER mode does not apply to AC.

4.6.2 Connections to Circuit

For most measurements, either the probe or the red and black test leads may be used. The probe cable is shielded to reduce pickup from stray electrical fields. Use only the red and black test leads for 1000 volt range measurements and for 1A and 10A current measurements. The shielded lead adds 105 pF capacitance to the basic

45 pF of the Instrument input terminals. The total of 150 pF capacitance has a reactance of about 50 kΩ at 20 kHz. This impedance is much lower than the 10 MΩ input resistance of the Instrument, and often must be taken into account when making measurements in high-impedance circuits.

4.6.3 Another way to reduce loading is to connect short, unshielded leads directly to the input terminals of the Instrument. This reduces capacitance to about 1/3 of that with the probe, and consequently increases the Instrument impedance to approximately 150 kΩ at 20 kHz.

4.6.4 Impedance vs Pickup

Open-circuit impedance of the Model 303-3XL at 60 Hz power line frequency is practically the full 10 MΩ, even with the probe connected. Most measurements of AC for which this type Instrument is used are of relatively low circuit impedance.

4.6.5 Unshielded test leads can pick up many millivolts of stray 60 Hz signal when open-circuited; however, the pick up usually is negligible when the leads are connected into the usual circuit. This is demonstrated by your noting stray pick up with the open test leads connected and the Instrument controls set to 30 mVAC. A large pointer deflection will be seen. By connecting the leads across a 10 kΩ resistor, the pointer deflection falls below 1 mV.

4.7 DC CURRENT MEASUREMENTS

Do not exceed the rated circuit to ground voltage. See item 2, Table 1-1 and the Safety Precautions tabulated in paragraph 4.2.

4.7.1 Review and comply with the PRELIMINARY NOTES, CHECKS AND ADJUSTMENTS, paragraph 4.3

4.7.2 Remove all power from the circuit being measured and fully discharge all capacitors by appropriate means. If the current to be measured is in the range of 1 μA to 30 mA, use the + input and

COMMON jacks with the probe slide switch set to DIRECT, or with the red and black test leads. For 1A or 10A ranges, the red test lead goes into the 1A or 10A jack and the black test lead into the COMMON jack.

WARNING

To assure user safety and avoid damaging the Instrument, when the current to be measured is known to be 1.0 ampere or more and the circuit voltage exceeds 42.4 volts (DC, AC peak or DC + AC peak), connect the test leads permanently to the circuit by means of screw terminals or solder. If necessary, make up a set of leads for this purpose or modify a pair of Simpson Catalog Number 07500 test leads by removing the alligator clips and shields and soldering a semi-permanent connection to the circuit being measured.

4.7.3 Turn the range selector to the desired current position and the mode selector to ±DC. If the current to be measured is unknown (but not over 10A), begin in the 10A current range.

4.7.4 Clip the test leads to the points in the circuit being measured for current; i.e., open up the circuit so that the current will flow through the Instrument. Recognize current polarity by connecting the red lead (+) or probe tip to the current source (+) and the black lead to the current "sink" (−) in the circuit. The right hand LED will flash when conventional current is flowing into the input (or 1A or 10A jack), through the meter and out the COMMON jack.

4.7.5 Apply power to the circuit being measured. **Do not** touch the test leads or the Instrument while power is on. The value and polarity of the current being measured is indicated on the meter.

4.7.6 Remove all power from the circuit being measured; fully discharge all capacitors by appropriate means. Disconnect the test leads from the circuit and restore the break which was made in the circuit measured.

4.7.7 Turn the range selector to the 300V (1000V) position.

4.7.8 Zero center DC current measurements may be made from center scale zero reference by turning the mode selector to ZERO CENTER. The blue calibrated scales at their maximum scale indicate half the range value to which the selector switch is set. Positive currents flowing into the red lead or probe tip are read up-scale from center zero (0). When used as a null or balancing indicator, the Instrument's current range may be selected that gives optimum adjustment sensitivity.

4.8 AC CURRENT MEASUREMENTS

Do not exceed the rated circuit to ground voltage. See item 2, Table 1-1 and the Safety Precautions tabulated in paragraph 4.2.

Follow the same directions as for paragraph 4.7, heeding all WARNINGS and CAUTIONS. Turn the mode selector to AC instead of ±DC. Refer to Section I, Table 1-1, paragraph 3, for accuracy vs frequency and other considerations for AC operation.

4.9 dB SCALE

dB is defined as follows: $20 \log V_1/V_2$ (voltage)
$20 \log I_1/I_2$ (current)
$10 \log P_1/P_2$ (power)

Begin at any dB reading as reference and add or subtract the final dB value to obtain the increased or decreased voltage, current or

power level. The dB expression is related to voltage, current or power ratio as shown in the following examples.

dB	V_1/V_2 or I_1/I_2	P_1/P_2 (when $R_1 = R_2$)
0	1	1
3	1.414	2
−3	0.707	0.5
10	3.16	10
−10	0.316	0.1
20	10	100
−20	0.1	0.01
30	31.6	1000
−30	0.0316	0.001
40	100	10000
−40	0.01	0.0001
50	316	100000
−50	0.00316	0.00001
60	1000	1000000
−60	0.001	0.000001

To read dB ratio, add the two related dB readings algebraically. For each change of range between the readings, add +10 dB per range higher and −10 dB per range lower. Ratios of power equivalent to ratios of voltage given in the chart technically are correct as long as the voltage is across (or current is thru) the same resistance value. Zero (0) dBm power level is defined as one milliwatt into 600 ohms resistance (0.775 V rms). Therefore, dBm power level may be read directly from −20 to +2 dBm on the 1V scale of the Model 303-3XL, and from −50 to +62 dBm by adding ±10 dBm per range change above and below the 1V setting of the selector switch.

4.10 CAPACITOR CHECKS

a. While this Instrument does not include a formal and accurate means for measuring capacitance, it can be used to confirm the probable utility of a capacitor.

b. Set the Instrument controls for measurement of very high resistance on either + or − DIODE OHMS.

c. Connect the test leads to the terminals of a good capacitor, and note that at first the meter pointer deflects downscale; then it returns to a higher reading which is the leakage resistance of the capacitor.

d. With most capacitors, the leakage resistance is at least many hundreds of megohms, so ordinarily you would use the Rx1MEG range. However, to hasten the charging process with capacitances larger than (say) 0.1 microfarad, you might prefer to use the Rx100K range instead.

e. Particularly when checking very small capacitances (below about 0.001 microfarad), you might find it helpful to accentuate the effect. Charge the capacitance in one direction; then reverse the test leads and recharge the capacitance in the opposite direction. The second "kick" will be more pronounced. Do not try to bring about the charge reversal by merely changing the mode selector switch from + DIODE OHMS to − DIODE OHMS; the normal transient disturbance of the meter pointer will mask the effect you are trying to see.

f. A "shorted" capacitor will produce a deflection which persists at an intolerably low resistance value for the circuit circumstance in which the capacitor will be used.

g. Connect an electrolytic or other polarized capacitor according to its polarity markings.

SECTION V

MAINTENANCE

5.1 GENERAL

The Model 303-3XL has been designed carefully and is constructed with high-quality components. By providing reasonable care, and following the instructions in this manual, the user can expect a long service life from his Instrument.

5.2 WARRANTY

The Simpson Electric Company warranty policy is printed on the inside front cover of the manual. Read carefully prior to requesting a warranty repair.

NOTE: For assistance of any kind, including help with the Instrument under warranty, contact your nearest Simpson Authorized Service Center for instructions. These are listed on the last pages of the manual. If you wish to contact the factory directly, give full details of the difficulty and include the Instrument model number and date of purchase. Service data or shipping instructions will be promptly sent to you. There will be no charge for repair of the instrument under warranty beyond one-way transportation charges. If an estimate of charges for non-warranty or other service work is required, a maximum charge estimate will be quoted. This charge will not be exceeded without your prior approval. Repair charges will be billed on the basis of cost.

5.3 SHIPPING

5.3.1 Pack the Instrument carefully, and ship it prepaid to the proper destination. Insure the shipment.

5.4 BATTERY AND FUSE COMPARTMENT COVER REMOVAL (See Figure 5-1)

WARNING

Remove all power and input connections to the Instrument prior to removing the battery and fuse cover. Do not operate the Instrument with this cover removed.

To install or replace battery and fuse, remove the battery and fuse compartment cover as follows:

a. Turn the range selector to the OFF position.

b. Disconnect the Battery Charger Adapter cord from the Instrument.

c. Loosen the single captive screw and remove the cover.

d. Reverse the above procedure when replacing the cover.

5.5 BATTERY INSTALLATION

5.5.1 Recommended Cell

One "D" size 1.25V, 1.2 ampere-hour, nickel-cadmium rechargeable (G.E. Model GC3 or equal). One "D" size 1.25V, 4 ampere-hour, nickel-cadmium rechargeable (ANSI K-90) may be substituted for longer life between charges. One "D" size 1.5V, Leclanche (carbon-zinc or Alkaline, NEDA 13 series) may be used. However, **the Battery Charger Adapter must not be used with the Instrument** when other than recommended **rechargeable** cell is installed. The disposable cells do not have provision for pressure release and can burst if charging is attempted.

5.5.2 Install the cell as follows:

a. Remove back cover per paragraph 5.4.

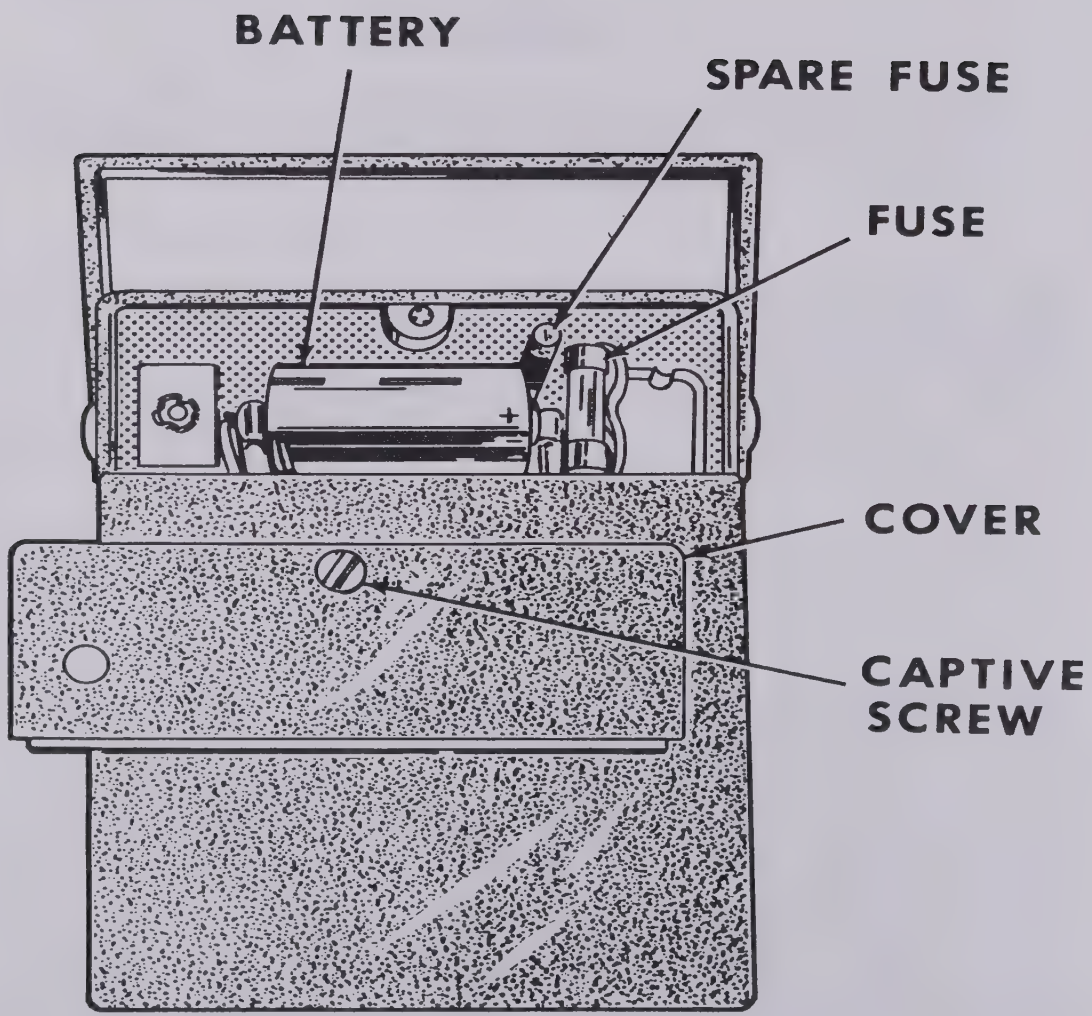

Figure 5-1. Battery and Fuse Compartment Removal

b. Insert the negative (−) side first. Push against the negative (−) terminal spring clip and then gently push the positive (+) side of the cell into place.

c. Replace the cover.

d. For battery charging, refer to paragraph 4.3.3.

e. Test the battery according to paragraph 4.3.2.

5.6 BATTERY CARE

5.6.1 Avoid allowing the cell to discharge completely. Keep trickle-charging when not in portable use. Check the battery condition per paragraph 4.3.2.

5.6.2 Recharge any newly installed (or discharged) rechargeable battery for a few minutes before operating the Instrument. To use right away, keep Battery Charger Adapter plugged in and do not operate on DIODE OHM Rx1 range for long periods. Check battery condition per paragraph 4.3.2 before use.

5.6.3 With nickel-cadmium cells installed in the Model 303-3XL, avoid storing in an area where the temperature goes above 140°F or below −40°F. Charge in the temperature span +32°F to +113°F. The recommended operating temperature range for these cells is −4°F to +113°F.

5.7 FUSE REPLACEMENT

5.7.1 Fuse replacement is indicated when there is no meter deflection via the input + and COMMON jacks, but LED flashing occurs and the battery checks OK.

5.7.2 Remove battery and fuse compartment cover per paragraph 5.4.

5.7.3 Locations of operating and spare fuses are shown in Figure 5-1.

5.7.4 Snap defective fuse out of fuse clips, grasping with fingers and pulling straight out.

5.7.5 Replace quick-acting 3AG 2A fuse. (The Instrument is delivered with a spare fuse in the spare fuse holder.) Snap into fuse clip by grasping with fingers and pushing straight down. Refill spare fuse holder with proper type fuse as soon as possible.

5.8 KNOB REMOVAL AND REPLACEMENT

WARNING

Do not operate the Model 303-3XL without knobs or with knobs which differ from those originally furnished with the Instrument. A shock hazard can exist between the shafts and power line ground if the Instrument is floated (above ground) either intentionally or accidentally. The knobs supplied with the Model 303-3XL insulate the user from shafts.

5.8.1 The mode selector and OHMS ADJ. knobs are push-on, pull-off, type on flatted shafts.

5.8.2 The central range knob has a metal insert and uses a knurled cup point set screw; it is not self-aligning. To remove, place switch in OFF position (the LED ceases to flash). Loosen set-screw and pull off. To replace, push on, align knob pointer with OFF index and tighten set screw securely.

5.9 PREVENTIVE MAINTENANCE

5.9.1 Daily Care

a. Immediately clean all spilled materials from the Instrument and wipe dry. If the spillage is corrosive, use a suitable cleaner to neutralize the corrosive action and remove the spillage.

b. Whenever the Instrument is not in use, rotate the range selector switch to the OFF position.

c. Avoid prolonged exposure or usage in areas which are subject to temperature and humidity extremes, vibration or mechani-

cal shock, dust or corrosive fumes, or strong electrical or electromagnetic interferences.

5.9.2 Monthly Care

a. Verify Instrument accuracy by performing operational checks using known, accurate, stable sources. If the need for recalibration is indicated, contact your nearest Simpson Authorized Service Center (refer to last pages of this manual).

b. If the Instrument has not been used for 30 days, check the battery condition and recharge if necessary.

c. Using a lintless wiper wadded to fit the input terminal depression; dip sparingly in fresh denatured alcohol solution and wipe clean all 6 of these holes. Turn meter upside down to prevent alcohol from getting into interior of Instrument. Wipe again with dry wiper.

d. Inspect probe cable and test lead cable insulation thoroughly for signs of cracks or abrasions. Replace defective leads or cable for your safety. Do not use leads of lesser quality than those furnished with Instrument.

5.9.3 Annual Care

It is recommended that the Instrument be returned annually to your nearest Simpson Authorized Service Center, or the factory, for complete over-all check, adjustment and calibration.

5.9.4 Storage

When the Instrument is not in use, store it in a room free from temperature extremes, dust, corrosive fumes, and mechanical vibration or shock. If storage time is expected to exceed 30 days, remove the batteries.

SECTION VI

ORDERING INFORMATION, SCHEMATIC DIAGRAM & AUTHORIZED SERVICE CENTERS

Table 6-1. Supplies Furnished With Model 303-3XL

Quantity	Description	Catalog No.
1	Test Lead Set	00115
1	1.25V nickel-cadmium D Cell rechargeable, G.E. Model GC3 or equal	
1	Probe, Isolation DCV/Direct	00182
1	Battery Charger Adapter	12248
1	Operator's Manual	5-116834
2	Fuse (and spare) 2A/250V 3AG Quick-acting	

Table 6-2. Accessories Available for Model 303-3XL

Description	Catalog No.
Retractable Grip-Tip lead probe (for use with Cat. No. 00115 lead)	00118
High Voltage Probe, 30,000 VDC	00167

Table 6-3. Replacement Parts List

Reference Symbol	Description	Part No.
C1	Capacitor, 0.01μF, 500 WVDC	1-114872
C2	Capacitor, 12 pF, $\pm$10%, 500 WVDC	5-116824
C3	Capacitor, 18 pF, $\pm$10%, 500 WVDC	5-116825

Reference Symbol	Description	Part No.
C4	Capacitor, Trimmer, 3-20 pF, 500V	5-116838
C5	Capacitor, 0.1μF, ±10%, 400V	5-110738
C6	Capacitor, Trimmer, 3-20 pF, 500V	5-116838
C7	Capacitor, 82 pF, ±5%, 500V	5-116827
C8	Capacitor, 1100 pF, ±1%, 33V	5-116829
C9	Capacitor, 11000 pF, ±1%, 33V	5-116828
C10	Capacitor 0.12μF, ±5%, 100V	5-116858
C11	Capacitor, 5 pF, ±0.5%, 500V	5-116826
C12	Capacitor, 0.1μF, ±10%, 100V	5-113612
C13	Capacitor, 6 pF, ±10%, 500V	5-116823
C14	Capacitor, 6 pF, ±10%, 500V	5-116823
C15	Capacitor, 15μF, +50% −20%, 20V	5-115534
C16	Capacitor, 15μF, +50% −20%, 20V	5-115534
C17	Capacitor, 220μF, +75% −10%, 10V	5-117208
C18	Capacitor, 220μF, +75% −10%, 10V	5-117208
C19	Capacitor, 3.3 pF, ±5%, 1000V	5-117138
C20	Capacitor, 5000 pF, ±20%, 3000V	5-113760
C21	Capacitor, 10 pF, ±10%, 500V	5-117212
C22	Capacitor, 390 pF, ±5%, 63V	5-117140
C23	Capacitor, 0.1μF, ±10%, 100V	5-113612
B1	Battery, 1.25 volts, size "D" nickel-cadmium, rechargeable	5-117141
D1	Diode, Germanium, 1N695	5-112232
D2	Diode, Germanium, 1N695	5-112232
D3	Diode, Germanium, 1N695	5-112232
D4	Diode, Germanium, 1N695	5-112232
D5	Diode, Silicon, 10D4	1-110051
D6	Diode, Silicon, 10D4	1-110051
D7	Diode, Silicon, 1N914	5-112004
D8	Diode, Silicon, 1N914	5-112004
D9	Diode, Silicon, 1N914	5-112004
D10	Diode, Silicon, 1N914	5-112004
D11	Diode, Silicon, 1N914	5-112004
D12	Diode, Silicon, 1N914	5-112004
F1	Fuse, 2A, 250V, 3AG Quick-acting	1-112911

Reference Symbol	Description	Part No.
IC1	Integrated Circuit, Op Amp	5-116853
Q1	Transistor, NPN, Silicon, MPS3394	5-112631
Q2	Transistor, NPN, Silicon, MPS3394	5-112631
Q3	Transistor, FET, N-Channel, Dual 2N3958	5-116855
Q4	Transistor, FET, N-Channel, Single ITE4338	5-116856
Q5	Transistor, PNP, Germanium, 2N1303	5-116854
Q6	Transistor, PNP, Germanium, 2N1303	5-116854
Q7	Transistor, NPN, Silicon, 2N3565	5-114689
Q8	Transistor, NPN, Silicon, 2N3565	5-114689
Q9	Transistor, NPN, Silicon, 2N3565	5-114689
Q10	Transistor, NPN, Silicon, 2N3565	5-114689
Q11	Transistor, NPN, Silicon, Dual, TD-101	5-113035
R1	Resistor, 1 MΩ, ±10%, 1/4W	5-113626
R2	Resistor, 33 kΩ, ±10%, 1W	1-113933
R3	Resistor, 9 MΩ, ±1/2%, 1/2W	5-116846
R4	Resistor, 900 kΩ, ±1/2%, 1/4W	1-110735
R5	Resistor, 90 kΩ, ±1/2%, 1/4W	1-110737
R6	Resistor, 9 kΩ, ±1/2%, 1/4W	5-116845
R7	Resistor, 3.03 kΩ, ±1%, 1/4W	5-116844
R8	Resistor, 95.9Ω, ±1%, 1/4W	5-116842
R9	Resistor, 90 Ω, ±1%, 1/4W	5-116841
R10	Resistor, 900 Ω, ±1/2%, 1/4W	5-116843
R11	Resistor, 485 Ω, ±1%, 1/4W	5-115597
R12	Resistor, 10.2Ω, ±1%, 1/2W	5-117113
R13	Resistor, 10 kΩ, ±10%, 1/2W	1-111671
R14	Resistor, Variable, Tandem Construction	5-116782
R14F	Front Section, 10 kΩ, ±10%, 1/2W	5-116782
R14R	Rear Section, 200 Ω, ±20%, 1/2W	
R15	Resistor, 25 kΩ, ±1%, 1/4W	1-110162
R16	Resistor, 123.5 Ω, ±1%, 1/4W	5-112939
R17	Resistor, 5.8 kΩ, ±1%, 1/4W	5-115681
R18	Resistor, Variable, Trimmer, 100Ω, ±30%, 1/4W	5-113011
R19	Resistor, 562Ω, ±1%, 1/4W	5-117115
R20	Resistor, 177Ω, ±1/2%, 1/4W	5-116847
R21	Resistor, 49.85 kΩ, ±1%, 1/4W	5-115877

Reference Symbol	Description	Part No.
R22	Resistor, 49.85 kΩ, ±1%, 1/4W	5-115877
R23	Resistor, Variable, 6 kΩ, ±10%, 1/2W	5-116781
R24	Resistor, 1 kΩ, ±1%, 1/4W	1-117058
R25	Resistor, 270Ω, ±10%, 1/4W	5-114969
R26	Resistor, 9.12 kΩ, ±1%, 1/4W	5-115920
R27	Resistor, 11Ω, +5%, 1/2W	5-112642
R28	Resistor, 2.7 kΩ, ±10%, 1/2W	1-113942
R29	Resistor, Variable, Trimmer, 20k, ±30%, 1/4W	5-116850
R30	Resistor, 724.8 Ω, ±1%, 1/4W	5-116848
R31	Not Used	
R32	Resistor, 5.6 kΩ, ±10%, 1/4W	5-114975
R33	Resistor, Variable, Trimmer, 5 kΩ, ±30%, 1/4W	5-117305
R34	Resistor, 1 kΩ, 5%, 1/2W	1-111606
R35	Resistor, 1 kΩ, 5%, 1/2W	1-111606
R36	Resistor, 2.2 kΩ, ±5%, 1/2W	1-118748
R37	Resistor, 180 kΩ, ±10%, 1/2W	5-114982
R38	Resistor, 27 kΩ, ±5%, 1/2W	1-111935
R39	Resistor, 27 kΩ, ±5%, 1/2W	1-111935
R40	Resistor, 47 kΩ, ±5%, 1/2W	1-110725
R41	Resistor, 2.4 k, ±5%, 1/2W	1-118198
R42	Resistor, 56 Ω, ±5%, 1/2W	1-110792
R43	Resistor, 12 kΩ, ±5%, 1/2W	1-118074
R44	Resistor, 27 kΩ, ±5%, 1/2W	1-111935
R45	Resistor, 47 kΩ, ±5%, 1/2W	1-110725
R46	Resistor, 47 kΩ, ±5%, 1/4W	5-113628
R47	Resistor, 3.03 Ω, ±1%, 1W	5-116840
R48	Resistor, 31.94 MΩ, ±1%, 1W	5-116849
R49	Shunt Assembly, 1 Ampere	10-650150
R50	Shunt, 10 Amperes	3-812006
R51	Resistor, 627.4 Ω, ±1%, 1/4W	5-117114
R52	Not Used	
SW-1	Switch, 4 Sections, 7 Positions	5-116774
SW-2	Switch, 3 Sections, 20 Positions	5-116775
T1	Transformer, DC Inverter, Toroid	5-116822
V1	Varistor, Silicon, SV1-LR	1-110670

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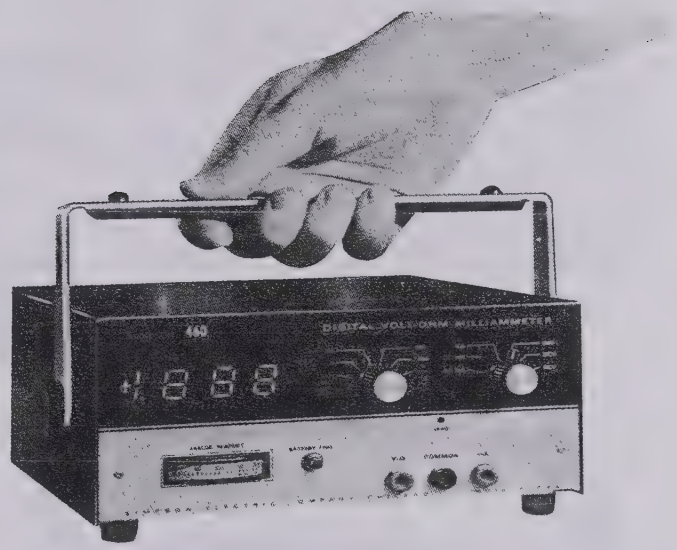

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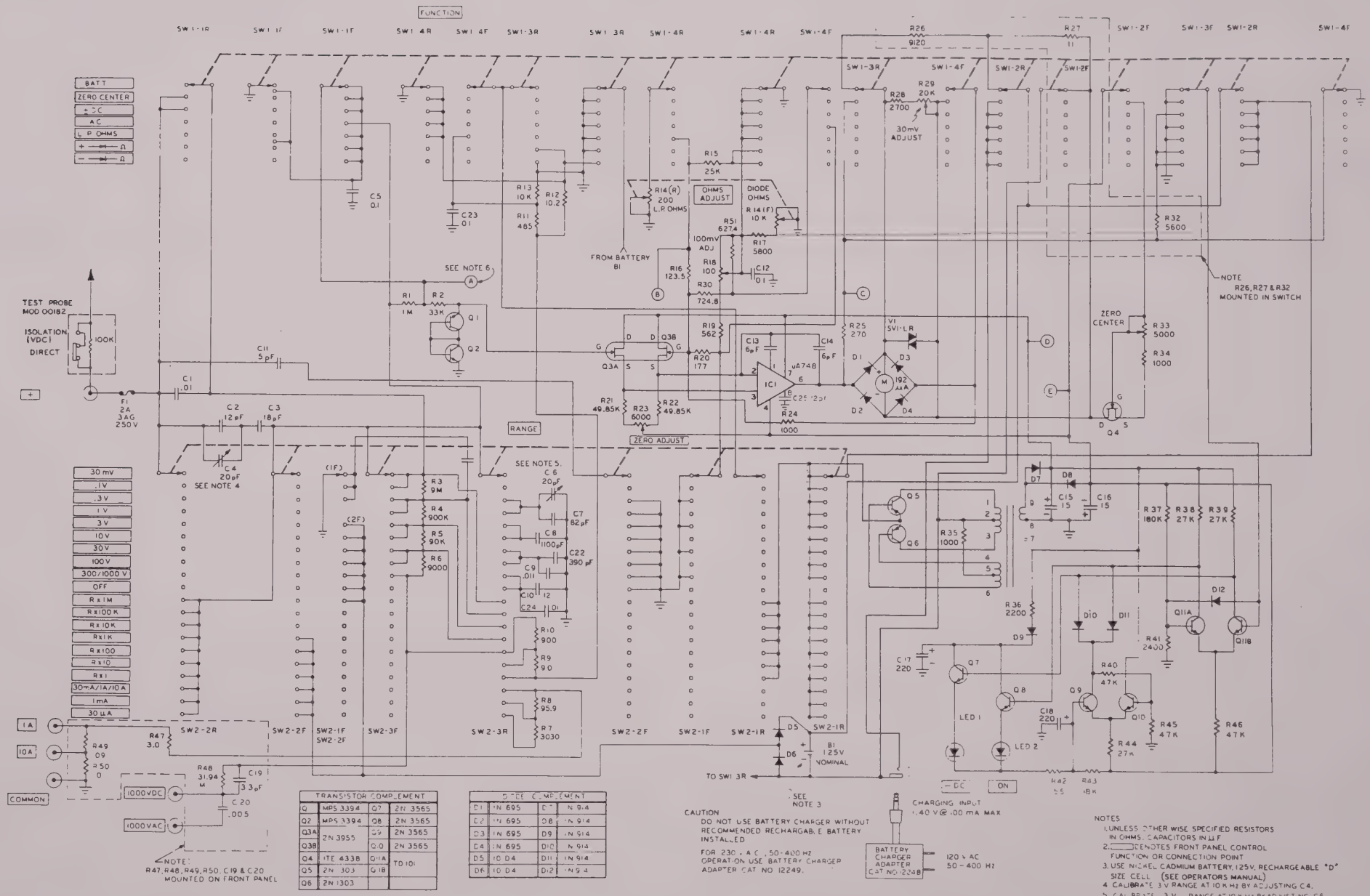

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